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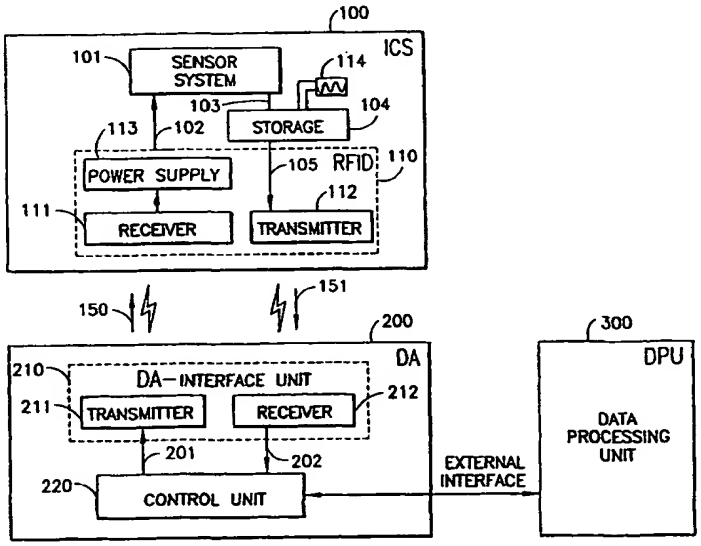
(54) Title: METHOD AND APPARATUS FOR AUTOMATED MEASUREMENT OF PROPERTIES OF PERISHABLE CONSUMER PRODUCTS



(57) Abstract

A method and apparatus for reporting dynamic properties of a product using radio frequency identification device technology. With this invention, an electronic tag (100) is equipped with a sensor (101) which determines dynamic properties of a product when the tag (100) is activated. The dynamic properties of the product are then either further processed into other dynamic properties. In any event either the former or the latter dynamic properties are then transmitted from the tag (100). Such dynamic properties could be the temperature of a product or the expiration date of the product derived from periodic measurements of the temperature of the product.

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METHOD AND APPARATUS FOR AUTOMATED MEASUREMENT OF PROPERTIES OF PERISHABLE CONSUMER PRODUCTS

Field of the Invention

The present invention relates to a method and apparatus for reporting dynamic product status information using Radio Frequency Identification Device (RFID) technology.

Background of the Invention

In storage units, such as a refrigerator, a medicine supply locker, or a warehouse, perishable items might exist that have expired or are near expiration. Examples of such are medical supplies, biological specimens or simply a carton of milk each with associated expiration dates. Similarly, containers might be near empty requiring the acquisition of new items to replenish the current stock. In general, the items in such a storage unit can be described by a set of measurable properties (e.g., expiration date, weight, temperature, etc.) which can be used to either determine further properties (e.g., expiration date can be a function of the temperature) or to initiate certain consumer actions (e.g., replenish stock, lower environmental temperature).

Inventory tracking systems using an RFID device are known, see for example, US Patents 5347263, 5280159, 5785181, 5611051, 5608193. One known system is the EASY Pass System used at highway toll booths in the USA. Such systems are based on passive devices, i.e. an ID is hard coded into an electronic tag which is interrogated using RFID technology when a vehicle passes by an toll booth. That ID is then used to charge the consumer account associated with the ID. However, there is a need for inventory tracking systems which incorporate active sensors to determine dynamic properties such as weight, temperature and expiration date information.

Disclosure of the Invention

In one aspect of this invention a method is described for determining and reporting on dynamic properties which can vary with environmental conditions of products using RFID technology. The current invention describes a method and apparatus for determining dynamic properties of products and for transmitting these properties using RFID technology.

It is a further aspect of this invention to determine properties of perishable and consumable items and to transmit these properties using RFID technology. Such products include groceries and pharmaceutical products.

Accordingly, this invention includes an electronic tag for reporting dynamic properties of a product, where the tag has at least one sensor for determining the dynamic properties of the product and transmitting the determined properties from the tag or storing the properties when the sensor is activated with a radio frequency identification (RFID) device. Preferably the dynamic properties comprise sensory data, such as one of the following: weight, temperature, and expiration date. More preferably the sensor comprises a device for measuring temperature, for example a thermistor. Alternatively the sensor comprises a device for measuring weight, for example a pressure sensitive capacitor. As a further alternative the sensor comprises a device for measuring physical properties of the product.

This invention also provides for a method of reporting the dynamic properties of a product where the method comprises broadcasting an interrogation request, activating a sensor by transmitting an activation signal from an RFID device, where the activation signal is transmitted in response to the interrogation request. Finally, sensory data or dynamic properties of the product are determined by the activated sensor.

The present invention further provides an electronic tag reporting system for managing the handling of a product using dynamic properties of the product; the system comprising an electronic tag for reporting the dynamic properties of the product in which the tag comprises at least one sensor for determining the properties of the product, when the sensor is activated, and a radio frequency identification device for activating the sensor; and a digital assistant for processing the status information for product management. Preferably the digital assistant comprises a transmitter and receiver for interrogating the tag for the dynamic product properties, and a control unit for processing the dynamic product status information; the control unit preferably determines an expiration date as a function of dynamic properties and as a function of a fixed start date.

THe invention in a further aspect provides an electronic tag for determining dynamic properties of a product, the tag comprising at least one sensor, which when activated, determines dynamic properties of the product; and a radio frequency identification device for activating the sensor. Preferably the electronic tag further comprises a memory for storing the dynamic properties, and optionally further comprises a transmitter for transmitting the dynamic properties from the tag.

Depending upon which sensor sub-units are integrated into the device or tag, different properties can be measured and sent to the digital assistant for off-line processing. The tag can be attached to the product by either the manufacturer or the consumer. For example, an electronic tag with a weight sensor is placed at the bottom of the container which is placed on a flat surface so that the device is capable of measuring the weight of the container. The digital assistant will periodically poll the tag on the container and retrieve information as to the weight of the container. In another example, an electronic tag with a temperature sensing device could be attached to a perishable item to determine its expiration date where the digital assistant will process the temperature measurements that are periodically sent to it.

The electronic tag could incorporate micro sensors that can be implemented with just a few micro electrical components that can fit onto a single chip. Further, these micro sensors are readily available on the market at low cost.

Brief Description of the Drawings

Figure 1 schematically illustrates the integrated circuit sensor with the sensor system and the RFID of the dynamic inventory and property tracking system according to the invention is the digital assistant and the data processing unit.
Figures 2 to 4 illustrate various sensing devices that could be used to implement this invention.
Figure 5 schematically illustrates the sensor system of the integrated circuit sensor.
Figure 6 schematically illustrates the sensor logic device of the sensor system.

Detailed Description of the Drawings

An Integrated Circuit Sensor (ICS), shown in figure 1, combines, preferably on a single chip (100): (i) a sensor system (101) (e.g. an electronic weight scale, a temperature sensor, biosensors), and (ii) a radio frequency identification device, also known as RFID (110). The RFID typically includes a radio frequency receiver (111), a transmitter (112), and a power source (113). RFIDs are well known to those skilled in the art and are referenced below. The RFID is a radio frequency identifier which powers itself and connecting devices using power received from radio frequency waves (150) transmitted from an interrogating device, in our case the DA (200). Furthermore, the RFID device identifies itself by replying (151) with a unique digital signature to the interrogating device, again in our case a digital assistant (200).

The ICS (100) is integrated with the digital assistant (200) and optionally with an off-line data processing unit (300). The digital assistant's control unit (220), either being triggered externally by the data processing unit (300) or self triggered, periodically initiates (201) interactions with the ICS unit by broadcasting (150) an interrogation request, which is generated by a radio frequency activator (211) that is part of the interface unit (210). The control unit can be implemented using standard components such as a micro controller and memory well known to those skilled in the art. The radio frequency activates the RFID (110) through the receiver (111). The power supply (112) derives its energy from the radio frequency signal (151) used to interrogate the ICS. Using the energy of the power supply, the sensor system (101) is activated (102). The details on how sensors provide their measurement are described further on in more detail. The sensor in turn supplies its measurement either directly back to the transmitter (111) or to an optional storage component (104), which utilizes an optional power supply (114) to hold values for longer periods of time. Dependent on the RFID technology used, this active power supply (114) could be utilized by the RFID as well. The ICS still powered by the interrogation signal (151) then reflects the unit identification embodied into the RFID together with the measurement back to the digital assistant (152). The signal is received at the digital assistant (212), demodulated and provided (202) to the control unit. Here the data is either stored, used for further data processing or forwarded to the data processing unit for further processing.

In an alternate embodiment, the optional power supply powers the sensor system either permanently or periodically without requiring power from the RFID to trigger measurement.

Information related to an item to which the ICS is attached, must be initially entered into the system. Various embodiments are possible. Information access identification can by encoded in the RFID. For instance, the information could include a product information code. Examples of such information encoding schemes are bar codes. Alternatively, a printed identifier on the storage container itself (e.g. Bar code) could be scanned and related to the RFID stored on the integrated circuit. Relating an item in the storage unit with information in the digital assistant or the data processing unit can be done by sending an initial signal to the integrated circuit, receiving the response and correlating it in the digital assistant or data processing unit's information processing unit with the product information scanned using e.g. the bar code. Either way, the bar code information can than be used to access further product information. For instance, a sensor could consist of both an initial product date sensor and a temperature sensor. The product information accessible off-line could give additional

information on how an expiration date is to be determined based on the temperature profile and the initial product date. Such information is crucial for biological/medical products.

Below are several examples of electronic sensors that supply simple measurements that can be integrated into the ICS. These are readily available market items.

Figure 2 shows the weight sensor implemented using a flat plate capacitor cell (500) whose capacitance will change when pressure is applied on the plates. In particular, the voltage that is generated stands in relation to the applied pressure, albeit not in a linear one. In one embodiment, the ICS with pressure sensitive capacitor would be placed underneath the storage container, thus measuring the weight of the container. The capacitor requires a power source to charge it at the time of the measurement, but does not require a constant power supply.

Figure 3 shows the weight sensor implemented using a pressure sensitive piezoelectric transducer (510), which transforms mechanical pressure into electricity. In particular, the voltage stands in relation to the pressure, albeit not in a linear one. The ICS with integrated piezoelectric transducer could be placed underneath the storage container, thus measuring the weight of the container when placed.

Figure 4 shows how a temperature sensor can be implemented using a temperature sensitive resistor, also known as a thermistor (520). When supplied with power, the current, flowing through the resistor, is a function of the temperature surrounding the resistor.

The expiration date can depend on various environmental properties such as temperature and light. These properties have to be considered relative to some start date, such as a manufacturing date, packaging date, date of placement into the storage

The start date on the device may be recorded simply as a binary encoded string. This binary encoded string can be implemented with static memory, e.g. using bistable multivibrator technology or dynamic memory, either of which can be implemented with just a few transistors per bit. The expiration date is then dynamically updated based on observed sensor information and the start date.

Figure 5 illustrates the general design of a sensor system (101). This system utilizes the sensory data produced by a sensor, including but not limited to those sensors shown in Figures 2 to 4. This system also uses additional sensor system logic (600) to derive further dynamic product

properties. When a sensor sub unit is activated by an activation signal (102) from the RFID, the sensor provides the sensory data to the sensor logic device, which then determines a set of derived properties. The sensor logic device than writes the sensory data and the set (103a, 103b) of derived properties via (103b) to storage (104). The RFID then transmits the sensory data and the product properties to the digital system (200). Alternatively, the sensor system could have a sensor device logic which first retrieves the last produced set of derived properties and makes incremental changes to that last set of properties before writing them back to memory (104). The latter alternative, however, would require an active power supply (114).

In one embodiment of this invention, a dynamically adjusted expiration date derived by using a temperature sensor (520) and the sensor logic device (700) is shown in Figure 6. The voltage signal (103a) received from the temperature sensor is converted into a digital value (702) using A/D (analog to digital) converter logic (701). Then, this digital value (702) is used to perform a table lookup by indexing into a table (703) which maps the temperature into a change in the expiration date. Finally, the digital value is then forwarded to some additional compute logic (704) which computes the expiration date.

For example, the values stored in the table can be a rate of decay for the product to which the sensor system is attached. The computed logic can then retrieve a combination of the last stored values (601) of the computed expiration date, the time stamp and the last temperature and adjust the expiration date according with the algorithm encoded in the compute logic. The newly computed values (103b) are then written back to the storage.

Other sensors may be based on chemical decay, radio active decay, or biological activity (such as bacterial growth). The benefit of using these sensors, is that they can incorporate continuous changes rather than simply querying the device at discrete intervals.

All measurements can be directly used off-line or related to a product information sheet as described earlier in order to compute further properties. For example, the sensor data is sent to the digital assistant (200) which performs the computation of the expiration date in its control unit (220) or forwards the data to the data processing unit (300) for computation of the expiration date and other product management related activities, such as inventory control.

Off loading computationally intensive calculations can significantly reduce the complexity and cost of the ICS unit, in particular, the compute logic (704) of the sensor logic device (600).

CLAIMS

1. A electronic tag for reporting dynamic properties of a product, the tag comprising:

at least one sensor, which when activated determines dynamic properties of the product; and

a radio frequency identification device for activating the sensor and for transmitting latter the dynamic properties from the tag.

2. An electronic tag as claimed in claim 1, wherein the dynamic properties comprise sensory data.

3. An electronic tag as claimed claim 1, wherein the dynamic properties comprise at least one of the following: weight, temperature, and expiration date.

4. An electronic tag as claimed claim 1, wherein the sensor comprises a device for measuring temperature, for measuring weight, or for measuring physical properties of the product.

5. An electronic tag reporting system for managing the handling of a product using dynamic properties of the product, the system comprising: an electronic tag for reporting the dynamic properties of the product, the tag comprising:

at least one sensor for determining the properties of the product, when the sensor is activated, and a radio frequency identification device for activating the sensor; and

a digital assistant for processing the status information for product management.

6. An electronic tag reporting system as claimed in claim 5, wherein the digital assistant comprises:

a transmitter and receiver for interrogating the tag for the dynamic product properties, and a control unit for processing the dynamic product status information.

7. An electronic tag reporting system as claimed in claim 6, wherein the control unit comprises determining an expiration date as a function of dynamic properties and as a function of a fixed start date.

8. A method for reporting dynamic properties of a product, the method comprising:

broadcasting an interrogation request;

activating a sensor by transmitting an activation signal from a radio frequency identification device, the activation signal being transmitted in response to the interrogation request ;

determining the dynamic properties of the product by processing sensory data determined by the activated sensor.

9. An electronic tag for determining dynamic properties of a product, the tag comprising:

at least one sensor, which when activated, determines dynamic properties of the product; and

a radio frequency identification device for activating the sensor.

10. An electronic tag as claimed in claim 9, further comprising a memory for storing the dynamic properties.

11. An electronic tag as claimed in claim 9, further comprising a transmitter for transmitting the dynamic properties from the tag.

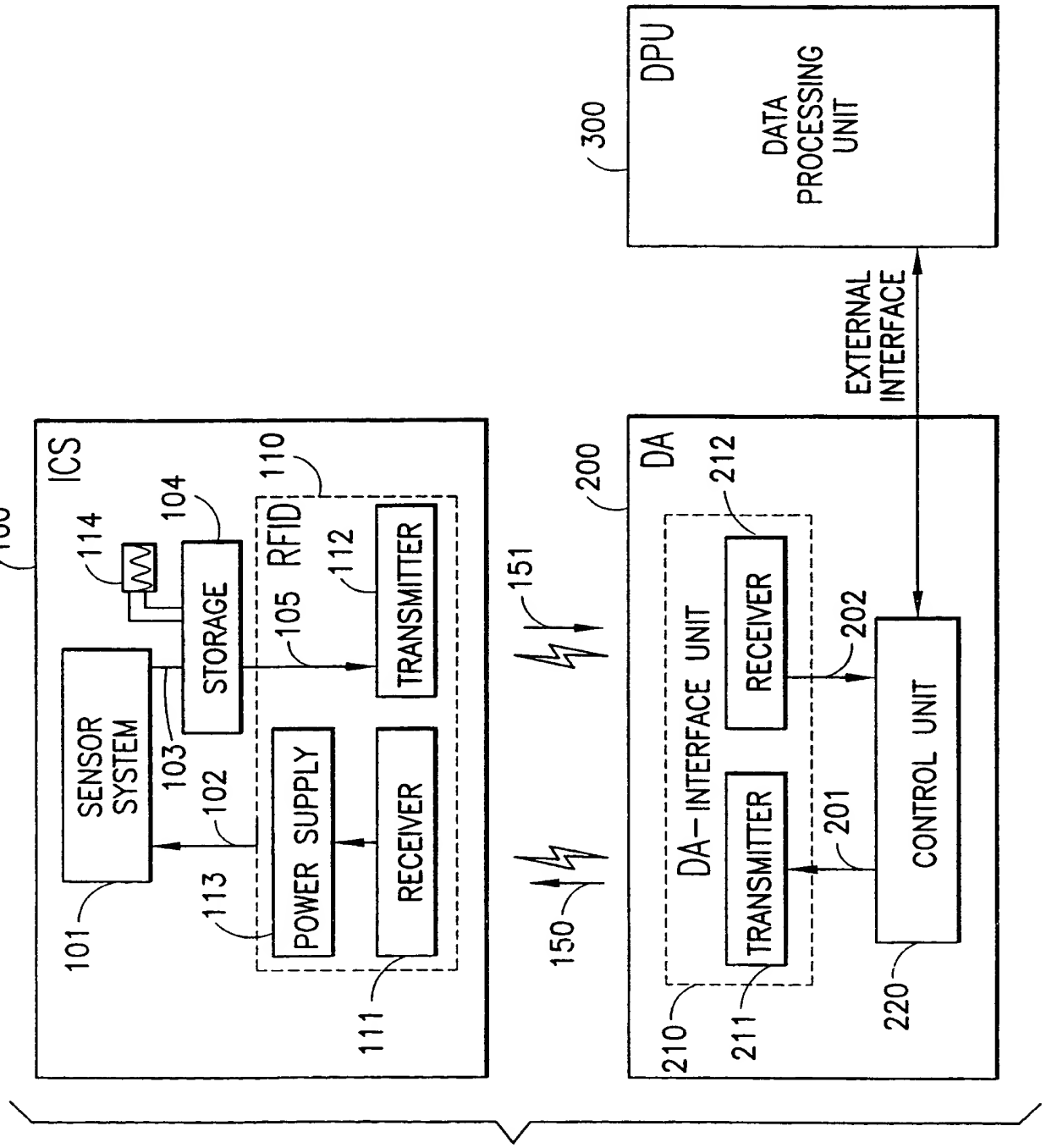

FIG.1

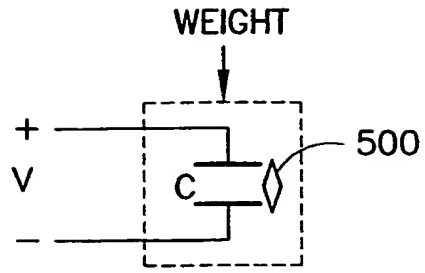

FIG.2

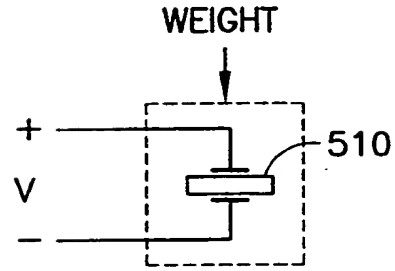

FIG.3

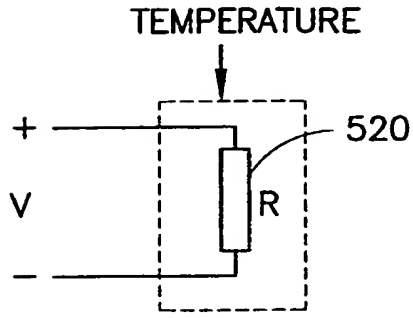

FIG.4

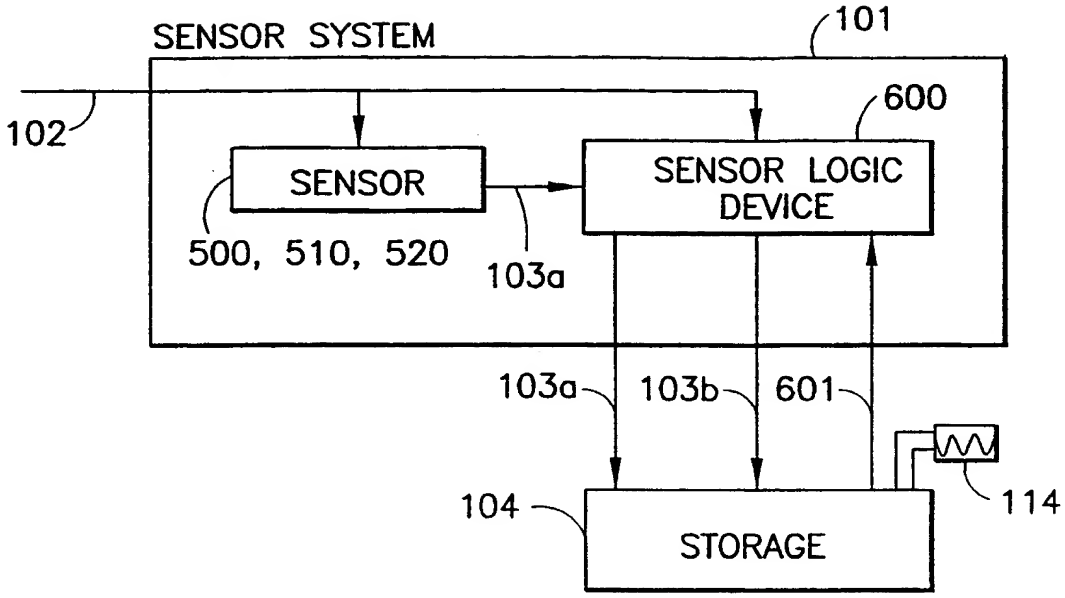

FIG.5

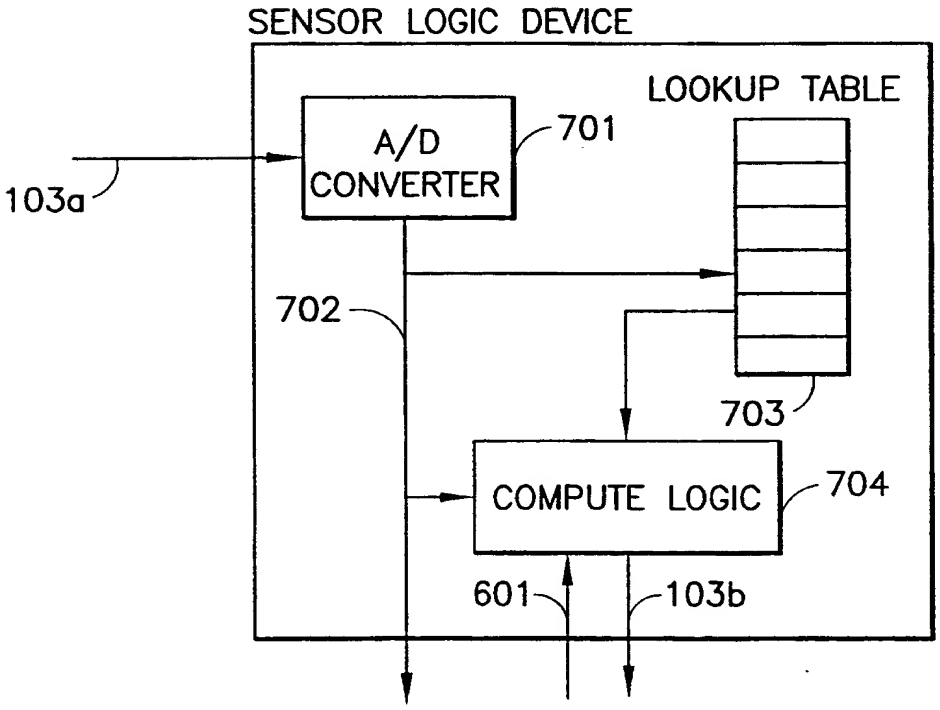

FIG.6

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06K19/07

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 798 694 A (REBER WILLIAM L ET AL) 25 August 1998 (1998-08-25) column 3, line 23 - line 55 column 4, line 41 - line 61 column 5, line 40 -column 7, line 12 figures 1,5,6	1-11
X	GB 2 308 947 A (I D SYSTEMS LTD) 9 July 1997 (1997-07-09) the whole document	1-11
X	FR 2 764 977 A (STELLA) 24 December 1998 (1998-12-24) page 2, line 1 -page 4, line 33 figure 1	1-11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 April 2000	04/05/2000

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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